Bol. Inst. Esp. Oceanogr. 16 (1-4). 2000: 149-156

BOLETÍN. INSTITUTO ESPAÑOL DE OCEANOGRAFÍA
ISSN: 0074-0195

Re-establishment programme for *Acipenser sturio* L., 1758: The German approach

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Received September 1999. Accepted June 2000.

ABSTRACT

Acipenser sturio L., 1758 was a prevalent species of the fish communities in all major German rivers' waters until the end of the 19th century. Since then, the population sizes decreased rapidly due to overfishing, pollution, and hydro-construction, and the last remaining population was observed in the Eider River until the 1960s. Recently, specimens have been observed in German waters only rarely. Until the end of the 1980s, neither politicians nor ecologists considered re-establishment measures feasible in Germany. In 1994, joint activities of scientists and aquaculturists led to the foundation of the Society to Save the Sturgeon (*A. sturio* L.), aimed at co-ordinating the *A. sturio* restoration measures in Germany. A federal programme was initiated, supporting in part the various subprojects dealing with this matter. Under a scientific co-operation agreement with France's Cemagref, the Institute of Freshwater Ecology and Inland Fisheries (IGB) in Berlin received, in May 1996, juvenile *A. sturio* for the establishment of a broodstock, as an *ex-situ* measure to save the species. The IGB also carries out research on various aspects of *A. sturio* biology. Together with the Cemagref, genetic analyses of remaining populations and specimens are conducted as a basis for a long-term breeding programme. The broodstock development is carried out in co-operation with the Research Institute for Agriculture and Fisheries of Mecklenburg-Vorpommern, where experiments with model species are performed within the framework of the programme. Evaluation measures for the restoration of *A. sturio* in the Odra and Elbe Rivers are carried out by the Society in collaboration with the Institute for Inland Fisheries of Poland. Additionally morphometric and meristic studies are conducted at the University of Rostock to characterise the species. The evaluation of the remaining populations in other European regions, in particular Romania and Georgia, is considered an important element for its future development. International co-operation in general is an essential aspect of future attempts to save the species.

Key words: Restoration, decline, broodstock, habitat, water management.

RESUMEN

Programa de recuperación para* Acipenser sturio *L., 1758: la propuesta alemana

Acipenser sturio *L., 1758 fue una especie frecuente en las comunidades de peces en las aguas de todos los grandes ríos alemanes hasta finales del siglo* XIX. *Desde entonces, los tamaños de las poblaciones disminuyeron rápidamente debido a sobrepesca, contaminación y obras hidráulicas, y la última población superviviente fue observada en el río Eider hasta la década de los sesenta. Recientemente, sólo raramente han sido observados ejemplares en aguas alemanas. Hasta finales de los ochenta, ni políticos ni ecologistas consideraron posibles las medidas de recuperación en Alemania. En 1994 las actividades conjuntas de científicos y acuicultores llevaron a la fundación de la Sociedad para Salvar el Esturión (*A. sturio *L.), aspirante a coordinar las medidas de recuperación de* A. sturio *en ese país. Se inició un programa federal, financiando en parte distintos subproyectos. Bajo un acuerdo científico de cooperación con Cemagref de Francia, el Instituto de Ecología Dulceacuícola y Pescas Interiores (IGB) de Berlín recibió, en mayo de 1996, juveniles de* A. stu-

rio *para el establecimiento de un stock de cría, como una medida* ex-situ *para salvar a la especie. El IGB también investiga sobre varios aspectos de la biología de* A. sturio*; colabora con Cemagref en la realización de análisis genéticos de las poblaciones y de ejemplares remanentes como base para un programa de cría a largo plazo. El desarrollo del stock de cría se lleva a cabo en cooperación con el Instituto de Investigación para Agricultura y Pesca de Mecklenburg-Vorpommern, donde se realizan estudios experimentales con especies modelo dentro del marco del programa. Las medidas de evaluación para la recuperación de* A. sturio *en los ríos Oder y Elba se establecen por la Sociedad para Salvar el Esturión en colaboración con el Instituto de Pescas Interiores de Polonia. Adicionalmente se llevan a cabo estudios morfométricos y merísticos en la Universidad de Rostock para caracterizar a la especie. La evaluación de las poblaciones remanentes en otras regiones europeas, particularmente en Rumania y Georgia, se considera un elemento importante para su futuro desarrollo. La cooperación internacional en general es un aspecto esencial de los intentos futuros para salvar a la especie.*

Palabras clave: *Recuperación, declive, stock de cría, hábitat, gestión del agua.*

INTRODUCTION

Sturgeons and paddlefish exhibit unusual combinations of size, behaviour, habits, and life history characteristics, which make them highly vulnerable to impacts from human activities: fisheries, hydroconstruction, and habitat destruction and degradation (Rochard, Castelnaud and Lepage, 1990; Beamesderfer and Farr, 1997; Boreman 1997). It is therefore not surprising that most of the 27 sturgeon species are currently endangered (Birstein, Bernis and Waldman, 1997). However, the combination of the various anthropogenic impacts is different for each species, and also particular to each river system. The historical distribution and the present situation of the stocks of the Atlantic sturgeon *Acipenser sturio* L., 1758 are a good example.

A. sturio was originally found from the Black Sea via the Mediterranean and the eastern North Atlantic to the North, Baltic and White Seas (Holčík *et al.*, 1989). During the 19th and particularly the 20th century, the stocks decreased drastically (the history of this decline in the European countries is described in detail in several papers in this volume), and today *A. sturio* occurs with certainty in fresh waters only in the Gironde-Garonne-Dordogne basin in France (Rochard, Castelnaud and Lepage, 1990; Lepage and Rochard, 1995; Williot *et al.*, 1997).

The decline of the species in Germany will be described in more detail: historically, *A. sturio* played a major role in fisheries in German waters (Benecke, 1881; Quantz, 1903; Blankenburg, 1910; Seligo, 1931; Ehrenbaum, 1936), especially in the lower parts of these rivers: the Eider, Elbe, Ems, Odra, Pregel, Rhine, Weichsel and Weser. For the Weichsel or Vistula, archaeological remains from the first millennium indicate that up to 70 % of the protein consumed derived from sturgeons (Hoffmann, 1996). In the 18th and 19th centuries sturgeon fisheries were economically important. British trade companies owned the leases in the Gdansk and Pregel area of the Baltic. In Germany (figure 1), the Eider, Elbe and Rhine were especially important for sturgeon

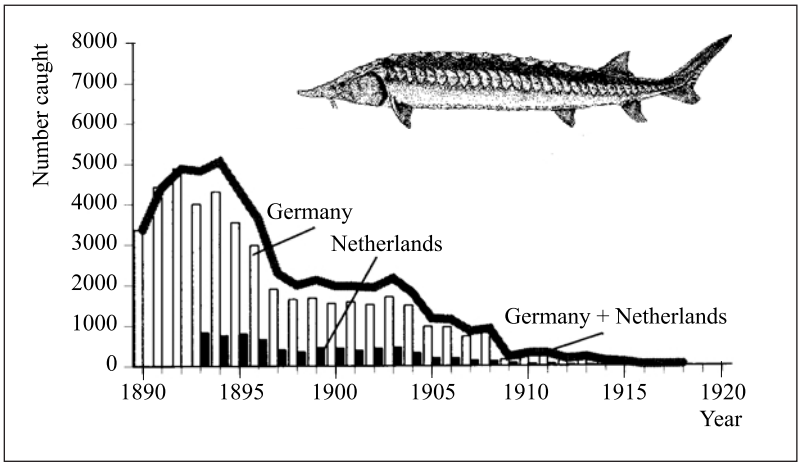

Figure 1. Total catch of *A. sturio* in Germany and Netherlands from 1879 to 1918. (After Lozan and Kausch, 1996 and Holčík *et al.*, 1989; modified)

fisheries (Mohr, 1952), trade (Kinzelbach, 1987, 1997), and caviar production. Until the end of the 19th century, the boom in sturgeon fishing continued, leading to a sharp decline in the catches from the Baltic Sea after 1894 (Debus, 1996). The level of landings was kept stable, despite the decline in riverine sturgeon catches, over 4-6 years by increased utilization of migrants in marine waters. The decline of *A. sturio* in Germany can be attributed to a combination of different impacts (Bonne, 1905; Bauch, 1958; Schirmer, 1994): overfishing, hydro-construction, degradation of water quality, and destruction of spawning habitat are the main factors contributing to the extirpation. The obvious increase in landings in the 1920s is a merely statistical problem. Since Hamburg had lost its sturgeon fleet due to the decrease of catches, the remaining fishing grounds were located in the Eider River. Therefore, sturgeon catches in the Wadden Sea were considered to be Eider River fish if not caught in the mouth of the Elbe River. This increased the proportion of the Eider catches. In any case, the sturgeon fishery continued despite the pressure imposed upon the fish. The management attempts (e.g. Ehrenbaum, 1916) presented in table I were all enforced too late, or were insufficient to effectively avoid the disappearance of the species.

Had fishing pressure been the major impact leading to the recruitment failure in all large German rivers, it should have been obvious in the Eider River, as well. The difference between the Eider and the other rivers is that only small settlements and little industry were located along the river in the 19th century. Apart from damming the tributaries Sorge and Treene in the 17th and 18th centuries and the upper reaches of the Eider in the 1860s, no major hydro-construction took place until 1890 (figure 2). Thereafter, the construction of the Kiel canal had a detrimental impact on the river's habitat, eliminating approximately 35 % of the catchment area from the main river (Fock and Ricklefs, 1996). The zone of tidal influence and sediment transport from the coastal areas into the river drastically increased (figure 3) due to flow reduction. This led to more frequent flooding, resulting in the second measure that finally broke

Table I. Measures taken to increase protection of *A. sturio* in northern Germany

1886		Proposed minimum size limit 1.5-2 m denied by authorities
1886 and 1891		Successful artificial reproduction (Quantz, 1903)
1890		Accepted minimum size limit 1.0 m, closed season July 26 - August 26
1898-1918:	Oste River	Closed spawning refuges comprising 7 km
	Elbe River	Closed season varying annually from July 15-August 26
1904	Elbe River	Closed post-spawning season (from August 1 on); deliberate minimum size limit 1.25 m
1914	Oste River	Closed areas increased comprising 19 river km
	Eider River	Prohibition of baited hooks; minimum size limits 1.25 m
1918	Oste River	Prohibition of eel longlines
1923		Minimum size limit 1.5 m
1924		Minimum size limit 1.2 m
1953	Eider River	Registration of catches for reproduction

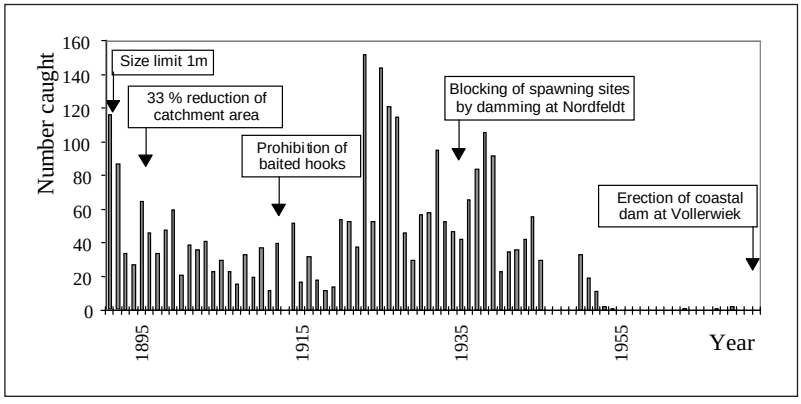

Figure 2. Sturgeon catches in the Eider River, northern Germany, between 1891 and 1973 (arrows indicate important events)

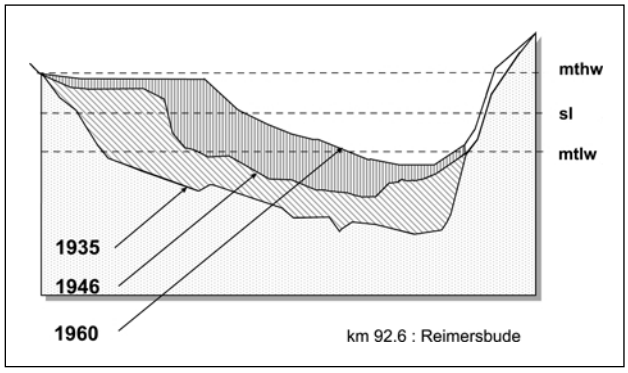

Figure 3. Reduction in cross section of the Eider River between 1935 and 1960 at river km 92.6 (mthw = mean tidal high water, sl = sea level, mtlw = mean tidal low water). (After Fock and Ricklefs, 1996; modified)

the back of the species in the Eider: erection of the dam at Nordfeld in 1934, which blocked the migration route to the spawning sites located upstream (Ehrenbaum, 1923). As a consequence of the recruitment failure, the sturgeon catches declined in the 1950s to incidental catches of single individuals. The idea in 1953 to artificially reproduce the few remaining fish arose too late (Spratte and Hartmann, 1992); no delivery of a ripe male or female was recorded in subsequent years. Additionally, the fishermen were not co-operative with this plan, slaughtering the catch before reporting it to the authorities (Spratte and Hartmann, 1992). In 1969, the last recorded sturgeon was caught from the Eider River (figure 4), just in time before the last migration obstacle, the dam at Vollerwiek in the river mouth, was constructed in 1972 to complete flood prevention.

The case of the Eider River demonstrates that each river system has to be analysed separately, and very carefully, to find the reasons for the decline of the population in question. The concentration of

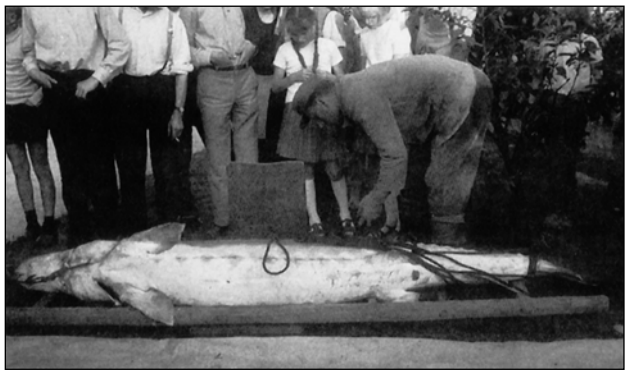

Figure 4. Female *A. sturio*, 2.6 m length and 105 kg weight, caught in the Eider River in 1969. (Photo: S. Spratte)

mature sturgeons in this river at a time when these fish had disappeared from all other German rivers indicates that homing in *A. sturio* might be a phenomenon more important than realised up to now.

HISTORY OF RE-ESTABLISHMENT FOR *A. sturio*

Until the 1990s the idea of conservation of a resource had not finally succeeded. Losing the species due to lack of prevention was widely accepted up to this time, as can be read between the lines of Nellen *et al.* (1994): "A restriction of the catches in the North Sea to protect the species (and to guarantee its survival) cannot be justified."

The international political readiness towards restoration measures and conservation of genetic diversity led to a series of international agreements on the conservation of endangered species (e.g. EU-Directive 92/43/EEC), leading to the protection and restoration of the required environment (Bern, Bonn conventions, RL 92/93/EEC). With increasing environmental consciousness, species that did not imply a commercial concern were integrated into active approaches. Finally, more complex structures were subjected to management measures, as expressed by the EUguideline demanding that management plans for entire water catchment areas of rivers are to be developed.

The dynamics and relationships between different sections of large river habitats have been identified in the past to a minor degree only. At the peak of the environmental impact of pollution, the idea to develop a more integrated understanding of the characteristics of river habitat was formed. River ecology became an increasingly dominant topic only recently (e.g. Baade and Fredrich, 1998; Buijse and Cazemier, 1998; Wolter and Vilcinskas, 1998; Thiel *et al.*, 1998; Neumann and Borcherding, 1998; Staas, 1998; Molls, 1998; Vricse *et al.*, 1998; Bischoff and Wolter, in press; Wolter, 1999).

The opinion concerning conservation measures for *A. sturio* in Germany in the 1990s also changed due to the side effects of German re-unification: the new political situation led to the foundation of the Institute of Freshwater Ecology and Inland Fisheries (IGB) in Berlin in 1992, providing major resources for studies on large rivers, e.g. the Elbe and Odra, which after re-unification became available for fundamental research and restoration measures (table II). The new ideas concerning restora-

tion of *A. sturio* were promoted by the success of the restoration of small streams (Bless, 1985) and the re-introduction of the salmon in tributaries of the Rhine (Schmidt, 1996) and recently the Elbe. Since the alteration of river management in the Rhine required symbolic parameters for the determination of environmental quality, the diadromous fishes seemed to fulfil the requirements quite precisely. They require accessibility to the rivers for reproduction and migration back into the sea; they need a highly oxygenated riverine habitat for the most vulnerable early life stages; they reach large sizes and are considered valuable and excellent game fish; and they are generally considered the typical victim of anthropogenic changes. During the marine phase, fisheries must play an important role for the survival of the species. All of this made the salmon the umbrella species for the restoration of the Rhine River (Neumann *et al.*, 1998). The reasons for not immediately considering *A. sturio* for restoration at that time, although the species is listed on the agenda of the International Commission for the Protection of the Rhine (IKSR) (Anon., 1987, 1991), were connected with its scarcity, deficits in the knowledge of its biology, and the comparatively longer time of its absence from the river (see above; Nellen *et al.*, 1994) because of its long generation span.

The increased interest in restoration of *A. sturio* in Germany in the early 1990s, the first positive results from the salmon restoration in the Rhine, as well as contacts with scientists working on restoration of the species, e.g. in Spain (Elvira, Almodóvar and Lobón-Cerviá, 1991), but particularly in France (Williot *et al.*, 1997), and the need to work on this subject by co-ordinating the various activities both nationally and internationally, led scientists, fish farmers and fishery administrators to the foundation of the Society to Save the Sturgeon (*A. sturio* L.) e.V. in Rostock in 1994. Subsequently, the Federal Agency for Nature Conservation began to support these activities providing the basic funding for the current programme in Germany.

CURRENT SITUATION OF RE-ESTABLISHMENT MEASURES AND FUTURE ACTIVITIES

The most important specific alternatives identified as potentially beneficial to the conservation of endangered sturgeon species are related to habitats, harvest, research, and culture stocking (Beamesderfer and Farr, 1997). The relative importance of these issues depends on the actual situation of the species in danger. *A. sturio* presently occurs with certainty only in the Gironde-Garonne-Dordogne basin in France, at a very low stock size level of a few thousand specimens exhibiting irregular natural spawnings (Rochard, Castelnaud and Lepage, 1990; Lepage and Rochard, 1995; Williot *et al.*, 1997). Therefore, research concerning broodstock development (Williot *et al.*, 1997; Williot *et al.*, 2000) and various life history stages is underway (Elvira (ed.), 2000) in France. The species has been protected in France since 1982. Habitat protection and restoration in the Gironde-Garonne-Dordogne basin is currently under discussion (Lepage, Rochard and Castelnaud, 2000).

The re-establishment measures in Germany, in order of importance, comprise the following issues: research, habitat protection and recovery, fisheries regulations, public awareness campaigns, and experimental restocking. Most of these activities are being carried out in close co-operation with many European institutions, in particular with Cemagref.

Table II. River systems in Germany potentially suitable for habitat restoration and sturgeon restocking measures

	Odra River	Elbe River	Rhine River
Length	865 km	1 091 km	1 320 km
Catchment area	120 000 km²	148 268 km²	185 000 km²
Bordering countries	Germany, Poland, Czech Republic	Germany, Czech Republic	Switzerland, France, Germany, Netherlands
Research topics concerning *A. sturio*	Evaluation concerning restoration measures (Gessner and Bartel, 2000)		The potential of the lower Rhine River as habitat for reproduction and early life stages of *A. sturio* (Schmidt, pers. comm.)

Research

The establishment of a broodstock is the base of the restoration programme in Germany, as the species has practically disappeared from German waters. This *ex-situ* measure began in 1996, when on the basis of a co-operation programme the IGB in Berlin received 40 juveniles from the Cemagref in Bordeaux, originating from artificial reproduction in 1995 (Williot *et al.*, 2000).

The first experience with this species indicated (Williot *et al.*, 1997) that this fish is difficult to maintain, in contrast to many other sturgeon species. Cemagref and the IGB therefore decided to apply different strategies when raising these fish, in order to gain as much knowledge as possible: in France the fish are fed on different species of shrimps only (Williot *et al.*, 1997), whereas at the IGB a variety of natural food items are and will be tested (Kirschbaum, Gessner and Williot, 2000). In France, fresh, brackish and salt water is used; at the IGB, freshwater only. There is one specimen of *A. sturio* living in salt water in the biological station at Heligoland. This specimen will be used for feeding trials involving live marine invertebrates. The weighing intervals are several months in France, and only two weeks at the IGB.

In the context of early sexual maturation of *A. sturio*, research into the impact of environmental factors on the maturation of gonads using model species are being conducted at the IGB and the Research Institute for Agriculture and Fisheries of Mecklenburg-Vorpommern.

As *A. sturio* historically comprised many geographically distinct populations (Holčík *et al.*, 1989), the genetic characterization of these populations, using both recent and museum material (Ludwig et *al.*, 2000), is another key element of the project. In addition, related species (Ludwig and Kirschbaum, 1998), in particular *Acipenser oxyrinchus* Mitchill, 1815, will be included in the characterization of the species. These data will be important for decisions concerning stocking trials in the different German rivers.

In close co-operation between the Cemagref in Bordeaux and the IGB, studies on the genetic structure of the remaining population in the Gironde and the captive broodstocks are being conducted, aimed at developing a breeding protocol for future reproduction strategies, thus, making it possible to minimize inbreeding and to increase genetic heterogeneity in both the German and French breeding groups.

In addition to the genetic investigations, attempts at morphological characterization of *A. sturio* and related species are underway at the University of Rostock.

Research on the remaining populations outside Germany, for instance in Romania, Albania, Georgia, and Britain, is considered essential to increasing our knowledge about the current status of the species, as well as the collection of material for the European broodstock.

Furthermore, recent data on sturgeon catches (Gessner *et al.*, 1999) and the problem of alien species are being investigated (Arndt *et al.*, 2000) in order to keep track of the main alterations in the environment and to establish a basis for future activities.

At the IGB, fundamental studies, including temperature preference (Staaks, Kirschbaum and Williot, 1999) and acoustic and feeding behaviour (e.g. amino acids as possible attractants), are planned.

Habitats

Studies on habitat requirements of early life stages of model species will be performed in co-operation with several institutions.

Evaluation of potential spawning habitats has been carried out from 1996 to 1998 in the Odra River, as outlined in Gessner and Bartel (2000), indicating a general potential for successful restoration in this river. More detailed characterization of the Odra and Elbe Rivers as potential habitats (see also table II) for early life stages of *A. sturio* are currently underway.

Fisheries regulations

Development of adapted fisheries techniques to reduce probability of bycatch of sturgeons in the coastal waters of the Odra River will be carried out in co-operation with the IGB and the Research Institute for Agriculture and Fisheries of Mecklenburg-Vorpommern.

Public awareness campaigns

Enhanced public awareness of *A. sturio* restoration in Germany will be an important element of

the project, aimed at the general public, but especially at fishermen and other users of the resources.

Experimental restocking

Last not least, after the first successful artificial reproduction (hopefully in a few years), future activities will include experimental release and tagging, tracking of fish for habitat analysis, and identification of potential threats.

ACKNOWLEDGEMENTS

The authors thank the Federal Agency for Nature Conservation for their encouragement and major material support for this programme. Mr Gessner was employed from 1996 to 1998 under the grant Nr. Az.: Z1.2-892 11-4/96 and from 1999 on under the grant Nr. Az.: Z 1.3-892 11-7/99, funded by the Federal Agency for Nature Conservation. We would like to thank Leonore Fischer for her help during the preparation of the manuscript. The comments of two unknown referees have improved the manuscript. Last but not least we would like to thank Benigno Elvira for his long-lasting patience in waiting for the manuscript.

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